DISTRIBUTION OF PARASITOIDS OF SCARAB LARVAE IN RELATION TO REMNANT VEGETATION: A PRELIMINARY ANALYSIS

A.J. CAMPBELL AND G.R. BROWN

Campbell, A.J. & Brown, G.R. 1994 06 30: Distribution of parasitoids of scarab larvae in relation to remnant vegetation: a preliminary analysis. *Memoirs of the Queensland Museum* **36**(1): 27-32. Brisbane. ISSN 0079-8835.

Distribution and abundance of scarab parasitoids (families Tiphiidae, Scoliidae and Tachinidae) were monitored using malaise traps in remnant vegetation and at varying distances up to 400m into adjacent pasture. Preliminary results indicate lower overall parasite diversity and abundance in grazed pasture. Tiphiid numbers decrease with distance from the remnant vegetation. Tachinid numbers were the highest at the forest margin and the lowest at a distance of 200m into the pasture, and increased again beyond 200m. Loss of the shrub component on farms through grazing pressure or deliberate clearing will result in a significant loss of beneficial insect biodiversity.□ *Scarabs, tiphiids, tachinids, remnant vegetation, malaise traps, distribution, abundance, pasture.*

A.J. Campbell, Regional Veterinary Laboratory, N.S.W. Agriculture, P.M.B. (UNE), Armidale, New South Wales, 2351. G.R. Brown, Biological and Chemical Research Institute, N.S.W. Agriculture, P.M.B. 10, Rydalmere, New South Wales, 2116. Present Address: Museum and Art Gallery of the Northern Territory, P.O. Box 4646, Darwin, Northern Territory, 0801; 28 July 1993.

Many scarabs are important agricultural pests. Their larvae are subterranean and feed on grass roots and other organic matter. Depending on seasonal conditions, larvae may be significant pasture pests. Some adults feed on tree leaves, especially eucalypts, and in large numbers cause serious defoliation. Prolonged and repeated defoliation over a number of seasons contributes to the death of trees (Landsberg & Wylie, 1988). On the northern tablelands of NSW, leaf-feeding scarabs, mainly of the genera *Anoplognathus* and *Sericesthis*, are one cause of eucalypt dieback. Adults of some scarab genera present (*Antitrogus, Dasygnathus* and *Rhopaea*) do not feed at all.

Most scarabs on the northern tablelands are indigenous. Goodyer (1985) and Davidson & Davidson (1992) suggested that scarabs can be controlled by maintenance of bushland on farms to provide habitat for their predators and parasites.

There are 3000 recognised species of scarab occurring in Australia (Lawrence & Britton, 1991). Adult taxonomy is reasonably well known while that of immature stages is not. Consequently, adults and larvae of many species cannot be correlated, except in a few regional areas and specific crops (e.g. McQuillan, 1985; Rogers, Brier & Houston, 1992).

Known insect parasitoids of scarabs are dipteran Tachinidae and wasps of Scoliidae and Tiphiidae. Colless & McAlpine (1991) recognised 542 tachinid species grom Australia, but only Dexiinae and *Palpostoma* (Tachininae: Palpostomatini) are considered scarab parasites (Crosskey, 1973a, 1973b; Barraclough, 1992). The Dexiinae contains many undescribed species.

Naumann (1991) recorded 25 scoliid species from Australia . All are believed to be exclusively parasitic on scarab larvae.

About 500 species of Australian Tiphiidae are named (Given, 1954). Few hosts are recorded (e.g. Burrell, 1935) for the family and it is assumed that all, except *Diamma bicolor* (a parasite of mole crickets), parasitise scarab larvae (Naumann, 1991). Their taxonomy is poorly known and papers e.g. Brown (1989) indicate that there may be at least twice as many undescribed species currently in collections. Hence, a conservative estimate is about 1500 Australian species.

Because of their diversity and abundance and their assumed host specificity, tiphiids are the most important insect scarab parasitoids. Several Australian species were tired to be introduced into New Zealand to control *Costelytra zealandica* (Given, 1953). All failed to establish (Given, 1968) either because the wrong parasites were selected, or from an incomplete understanding of the host and parasite biology.

This is a preliminary study of population dynamics of parasitoids of scarab larvae. The design was to test the hypothesis that scarab parasitoids kept to the remnant vegetation with

TABLE 1. Distribution of traps and distance away from remnant vegetation.

SITE	TRANSECT	TRAP No.	DISTANCE	TRANSECT	TRAP No.	DISTANCE
Daisy Hill	East-west	Series 1		North-south	Series2	
		1	—		7	—
		12	0		6	60
		5	50			
		2	100			
		3	240			
		4	280			
Fairburn	EW	Series 3		NS	Series4	
		21			29	—
		22	0		28	0
		23	100		27	100
		24	200		26[b]	200
		25	300			

[a] Distance from remnant vegetation in metres. No values are given for traps in the forest. Zero values indicate the trap is at the forest edge. [b] Trap 26 is at the intersection of transects 3 and 4.

little movement into the adjacent open pasture areas. These stands presumably provided shelter, food and other resources necessary for their survival. There are no detailed data on the movements of any scarab parasitoid groups in Australia, but tiphiids are not believed to move far out into open pasture (Ridsdill Smith, 1970).

METHODS

Parasitoid numbers were monitored at two sites 50km east of Armidale at the eastern edge of the tree-decline affected area of northern NSW. These sites were 5km apart on the adjacent properties of Daisy Hill and Fairburn.

Soils at both sites were dominated by granite parent material but a small area of soils were derived from sediments at Daisy Hill, and basalt at Fairburn. The vegetation was similar at both sites. The properties have undergone similar clearing, pasture improvement and grazing regimes. At Daisy Hill the forest/pasture boundary is well defined. The forest (a mixture of vegetation types, from heath to eucalypt woodland and forest) has undergone minimal disturbance by grazing and timber removal. At Fairburn, the pasture/forest boundary is not as well defined as most of the forest has had greater disturbance. There has been partial clearing within the remnant forest and livestock are not excluded. The transition from forest to pasture is more gradual.

Twenty malaise traps, as described by Townes (1972), were established: 8 at Daisy Hill and 12 at Fairburn. The distribution pattern of remnant vegetation allowed traps to be established only at intervals up to 400m. At each site, traps were located within the forest, at the forest edge and at intervals out into the adjacent pasture (at right angles to the forest boundary).

Traps were in 4 series based on site and transect orientation away from the remnant vegetation (Table 1.). At Daisy Hill, Trap 1 was in the forest, Trap 12 was at the forest boundary, whilst Traps 2-6 were in open pasture. Trap 7 was in a stand of leptospermum in forest otherwise free of understorey. At Fairburn, Traps 21 and 29 were in remnant vegetation areas dominated by *Eucalyptus* spp. with a variable shrub layer. Traps 23-28 were in the open and Trap 26 was at the intersection of 2 transects. Trap 29 was the only trap surrounded by an understorey of bursaria. Trap 30 was on a grazed wooded ridge top with few shrubs, over 600m away from the nearest trap (Trap 26, in open pasture). Traps 30-32 because of their location or different vegetation were not

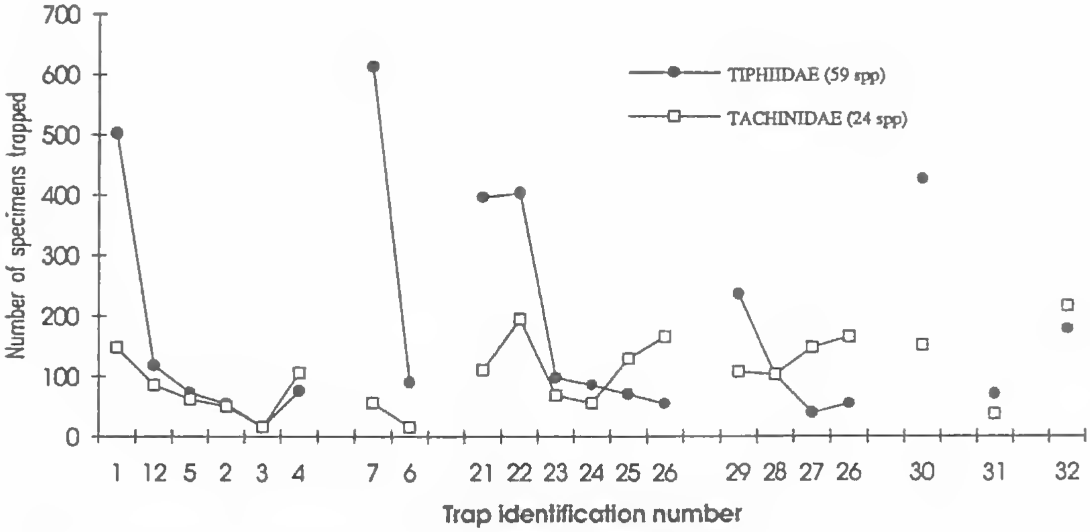

FIG. 1. Total number of Tiphiid and Tachinid scarab parasitoids collected per trap.

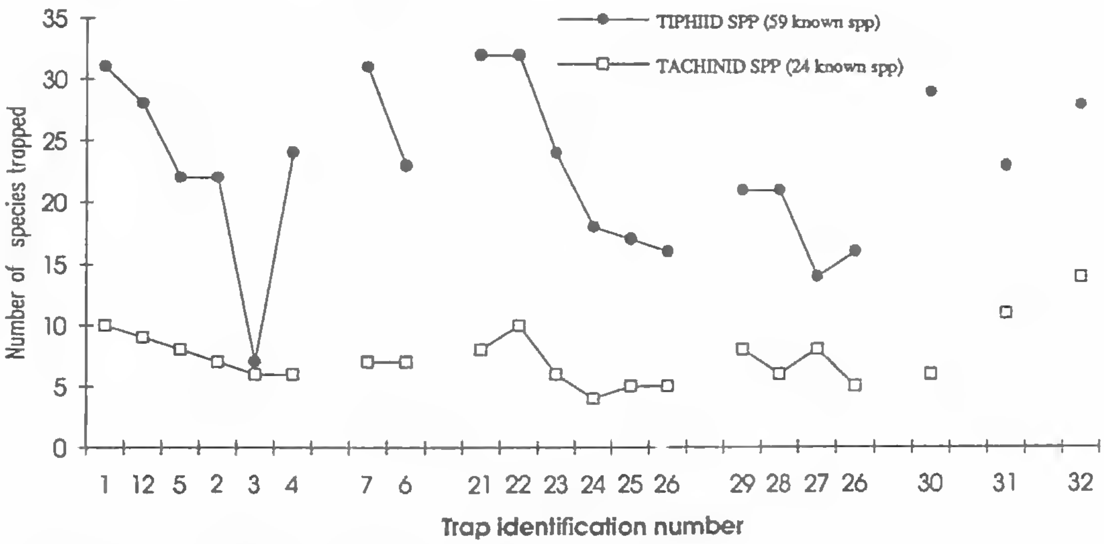

FIG. 2. Total number of Tiphiid and Tachinid species caught per trap.

included in any transect. Trap 31 was in low leptospermum scrub, surrounded by tall kunzea with few eucalypts, while Trap 32 was in a small natural clearing adjacent to the leptospermum. Traps 31 and 32 were near Trap 21.

All traps had the collection vessel outlet at the northern end (1.9m above ground level) and the longitudinal axis aligned north-south. Traps were individually fenced to exclude stock and grass within the enclosures was periodically mown.

Collection vessels on the malaise traps were changed every 7 days. Spiders on trap walls were removed to prevent predation. All adult tiphiids, tachinids (including non-scarab parasitising species), scoliids and scarab beetles within the traps were retained for identification.

RESULTS

Trapping data are presented for the period 16 August 1991-26 December 1992 (Table 2). Collected specimens were : 5311 scarab parasitoids, of which 3,274 are tiphiids (excluding the gryllotalpid parasite *Diamma bicolor*), 2,027 are

TABLE 2. Numbers of scarab parasitoids and scarab beetles collected.

TRAP NO.	TIPHIIDS	TIPHIIDS[1]	SCOLIIDS	TACHINIDS	TACHINIDS[2]	SCARABS	TOTAL
Daisy Hill Series 1							
1	503	496	0	541	148	30	1718
12	118	107	0	495	86	27	833
5	73	71	0	587	62	26	819
2	54	52	1	507	50	30	694
3	16	16	0	329	16	14	391
4	76	72	0	571	106	21	846
Daisy Hill Series 2							
7	612	590	1	823	56	22	2104
6	90	89	2	708	16	35	940
Fairburn Series 3							
21	396	258	0	482	111	0	1247
22	403	384	1	1839	194	0	2821
23	98	95	1	1326	68	0	1588
24	86	79	0	871	55	0	1091
25	70	63	3	742	130	0	1008
26[3]	54	52	1	579	166	0	852
Fairburn Series 4							
29	236	166	0	1165	108	0	1675
28	102	81	0	824	103	0	1110
27	39	35	0	508	148	0	730
26[3]	54	52	1	579	166	0	852
Fairburn							
30	427	355	0	768	152	1	1703
31	70	55	0	244	36	0	405
32	178	158	0	851	216	0	1403
TOTAL	3701	3274	10	14760	2027	206	23978

[1] Tiphiids exept *Diamma bicolor*. [2] Scarab parasitising Tachinids. [3] Included in 2 series but only once in total.

tachinids (scarab parasitising species) and 10 scoliids. At least 59 species of tiphiid, 24 tachinid and 4 scoliid species have been recognised. Also, a further 14,760 non-scarab parasitising tachinids of an unknown number of species, but potentially important in controlling other pests of both pasture and trees have been retained.

Of the 87 parasitoid species recognised, at least 39 are undescribed: 28 tiphiids and 11 tachinids; the incidence of undescribed species varies from very common to rare. Further breakdown to species level of tiphiids (see Appendix) is not meaningful because of the large number of undescribed species.

Tiphiid species' abundance using artificial frequency classes are: very common (>100 captures), 4; common (20-99), 19; uncommon (10-19), 13; rare (5-9), 4; very rare (<5), 19 captures. The last category include 3 species not captured in Malaise traps but only by sweep netting. Tiphiids were fewer along transects away from remnant vegetation (Table 2, Fig. 1).

Tiphiid diversity (i.e. species richness) is higher in the forest and at the boundary with the pasture. Diversity is lower further from the remnant vegetation (except for Traps 4 and possibly 27) and the same general trend occurs in tachinids (Fig. 2). Tiphiid catches, both in abundance and diversity, are lower at Trap 29 (surrounded by bursaria) than for traps near leptospermum. Tachinids appear unaffected by the dominant flowering species near the traps. Results from Trap 30 were higher than expected

Tachinids numbers generally peak at the interface between the pasture and forest and decline immediately adjacent to the forest edge before rising again. (Fig. 1).

The complex of 87 parasitoids potentially utilise the 25 scarabs species so far collected from the area.

Over 120 angiosperms (excluding Poaceae, Cyperaceae, Restionaceae, Jucaceae, Casuarinaceae) were recorded at Daisy Hill with fewer species at Fairburn. Species abundance varied across and between properties. Eucalypts did not flower during the sampling period. Parasitoids showed a general preference for low to medium height shrubs rather than prostrate plants. From sweeping and field observations, most adult parasitoids were found on leptospermum, baeckea and to a lesser extent bursaria. Regular sampling over other flowering plants (including hakea, kunzea, lomatia and epacris) gave insignificant catches.

DISCUSSION

A difference in habitat preference between the tiphiids and tachinids is suggested. Tiphiids have a distinct preference for flowering shrub or reduced light situations as found in forest areas, whilst tachinids appear more sun loving and capable of utilising open pasture.

The ratio of tiphiid:tachinid scarab parasitoids caught is greater than 1.6:1. Tiphiids canot be assumed to be the predominant parasitoids in the field because of differences in fecundity, potential flight behaviour and ability to be trapped.

Other apparent discrepancies in data (Series 1, Trap 4) may be due to soil texture changes, e.g. tiphiids were frequently observed hawking over a flat sandy area adjacent to Trap 4. Soil samples in this area had higher counts of parasitoid pupa and scarab larvae than elsewhere in the open. Scarab larvae were more common in the open pasture than the remnant vegetation areas. Scarab populations were non-random aggregations of mixed species.

Data from Trap 31 suggest the apparent inability of parasitoids to use leptospermum surrounded by taller dense kunzea, although catches show a high level of diversity.

It became apparent early in the study that certain families e.g. Scoliidae were seldom caught by malaise traps. They were observed flying around and over the traps in summer but too few specimens were collected to allow meaningful conclusions. It is unknown what other species avoided the traps or what proportion of the population was sampled.

The number of species found in the study highlighted the need for detailed taxonomic work in conjunction with field sampling. The similarity of some species and the number of recognisable but undescribed species creates problems if taxonomic services are not available.

Regardless of shortcomings in the technique used, there are no alternatives for continuous adult parasitoid sampling. Malaise traps returned species not collected by sweep netting once a week and the intensity of sampling should give a reliable indication of the total parasitoid biodiversity. Preliminary results indicate intensive regular sampling is necessary to pick up significant seasonal variation in both abundance and diversity of parasitoids.

To maximise parasitoids, access to appropriate flowering energy sources is needed. We found that leptospermum are the preferred species. A significant loss of beneficial insect biodiversity on farms will occur if grazing pressure or deliberate clearing destroys shrubs or forest remnants.

The results highlight the importance of adequate temporal and spatial sampling for biodiversity assessments. This study has provided data on only one phase of population dynamics of scarab parasitoids. Population recoveries after the serious drought across northern NSW will require further study and will provide a valuable contrast with these data.

ACKNOWLEDGMENTS

This project has been possible only because of the support of the Rural Industries Research and Development Corporation who funded the project and the generous assistance of Malcolm Ross and Allan McRae who allowed unlimited access to their properties for sampling. Chris Haywood, Duncan Mackay and Bruce Turnbull assisted with data collection.

LITERATURE CITED

BARRACLOUGH, D.A. 1992. The systematics of the Australian Dexiini (Diptera: Tachinidae: Dexiinae) with revisions of endemic genera. Invertebrate Taxonomy 6: 1127-1371.

BROWN, G.R. 1989. Revision of the Australian genus *Dorathhynnus* Turner (Hymenoptera: Tiphiidae). Journal of the Australian Entomological Society 28: 1-17.

BURRELL, R.W. 1935. Notes on the habits of certain

Australian Thynnidae. Journal of the New York Entomological Society 43: 19-26.
COLLESS, D.H. & McALPINE, D.K. 1991. Diptera (Flies). Pp. 717-786. In Naumann, I.D. (ed.), 'The Insects of Australia. A textbook for students and research workers'. (Melbourne University Press: Carlton).
CROSSKEY, R.W. 1973a. A revisionary classification of the Rutiliini (Diptera: Tachinidae), with keys to the described species. Bulletin of the British Museum (Natural History) Entomology, London, Supplement No. 19.
1973b. A conspectus of the Tachinidae (Diptera) of Australia, including keys to the supraspecific taxa and taxonomic and host catalogues. Bulletin of the British Museum (Natural History) Entomology, London, Supplement No. 21.
DAVIDSON, R. & DAVIDSON, S. 1992. 'Bushland on Farms: Do You Have a Choice'? (AGPS: Canberra).
GIVEN, B.B. 1953. General report on a search for parasites of Melolonthinae in Australia. New Zealand Journal of Science and Technology. Series B 34: 322-340.
1954. A catalogue of the Thynninae (Tiphiidae: Hymenoptera) of Australia and adjacent areas. Bulletin of the New Zealand Department of Scientific and Industrial Research 109.
1968. Resolute research to defeat grassgrubs. New Zealand Journal of Agriculture 116: 82-83.
GOODYER, G.J. 1985. Scarab grubs in northern tableland pastures. Department of Agriculture, NSW. Agfact P2.AE. 1.
LANDSBERG, J. & WYLIE, R.F. 1988. Dieback of rural trees in Australia. Geo Journal 17: 231-37.
LAWRENCE, J.F. & BRITTON, E.B. 1991. Coleoptera (Beetles). Pp. 543-683. In Naumann, I.D. (ed.), 'The Insects of Australia. A textbook for students and research workers'. (Melbourne University Press: Carlton).
McQUILLAN, P.B. 1985. The identification of root-feeding cockchafer larvae (Coleoptera: Scarabaeidae) found in pastures in Tasmania. Australian Journal of Zoology 33: 509-546.
NAUMANN, I.D. 1991. Hymenoptera (Wasps, bees, ants, sawflies). Pp. 916-1000. In Naumann, I.D. (ed.), 'The insects of Australia. A textbook for students and research workers'. (Melbourne University Press: Carlton).
RIDSDILL SMITH, T.J. 1970. The behaviour of *Hemithynnus hyalinatus* (Hymenoptera: Tiphiidae), with notes on some other Thynnidae. Journal of the Australian Entomological Society 9: 196-208.
ROGERS, D.J., BRIER, H.B. & HOUSTON, K.J. 1992. Scarabaeidae (Coleoptera) associated with peanuts in Southern Queensland. Journal of the Australian Entomological Society 31: 177-181.
TOWNES, H. 1972. A light-weight malaise trap. Entomological News 83: 239-247.

APPENDIX. Provisional taxonomic status of tiphiid genera collected at all sites.

Genus	No. of Species		
	Total	Described	Undescribed
Agriomyia	2	2	
Anthobosca	7	2	5
Ariphron	4	4	
nr *Ariphron*	2		2
Asthenothynnus	3	1	2
Diamma	1	1	
Eirone	7	1	6
Elidothynnus	1	1	
Guerinius	1	1	
Hemithynnus	2	2	
Lestricothynnus	1	1	
Lophocheilus	2		2
Neozeleboria	4	1	3
Phymatothynnus	4	1	3
Rhagigaster	4	4	
Tachynomyia	5	3	2
Thynnoides	2	1	1
Thynnoturneria	2	1	1
Zaspilothynnus	1	1	
TOTAL	55	28	27